V. DISCUSSION

1. Population Density

Densities of Bee-eater showed habitatwise variations with the river banks generally supporting the highest number of populations, the human habitations the least and the agricultural lands in-between. According to Lack (1933, 1937) and Hilden (1965), terrestrial animals seek their habitats rather than dispersing randomly and birds are no exceptions. The greater number of Bee-eaters at the river banks might be due to favourable features like greater vegetation densities and suitable soils for nest excavation. Influence of habitat structure (characteristics) on the avian distributions had been emphasized by Anderson (1976) as well. DeGraaf and Wentworth (1986) also reported a strong association between the measures of tree cover and insectivorous bird densities. Gole (1987) after studying the distribution of *M. orientalis* at Western Ghats, south of Bombay, reported a preference to thorny scrubs. The study area (river banks) resembles a scrub and bush type with short and stumpy vegetation. The high number of *Cassia occidentalis* at the river banks which are used for perching is another attractant to the Bee-eaters. Further, availability of suitable sites for easy excavation of nests at the river banks is another contributing factor to their preference by Bee-eaters. Relationships between availability of nest sites and bird numbers had been well documented already (Farner and King 1971, Alatalo *et al.*, 1984, Cody 1985). Cody (1980) further stated that birds adapt to areas with suitable habitat, which provides nesting site, nesting material, food and
protection from other species. The agricultural lands rank second to river banks in Bee-eater densities probably due to relatively rich supply of insects as pointed out by Lack (1966) that food is frequently the most important density dependent factor for birds. The least preference for human habitations in general, might be due to lesser food availabilities coupled with greater human disturbances. However, there is a preference for human habitations during winter months as the numbers of Bee-eater increased markedly in human habitations during that time. Role of weather, especially temperature and rainfall, in avian distribution and movement pattern, has been brought out by Andrewartha and Birch (1954). Moss et al. (1982) opined that weather can be important, either by itself or through its effects on food supplies; animals seem to limit their own numbers below any threshold set by weather, food, disease, predation, parasites or places to live. From the foregoing discussion it is well brought out that the factors that influence the Bee-eaters habitatwise distribution are vegetation, nest availability and insect food availability. A complete understanding of their habitat preference requires quantified information on births, deaths, immigration, emigration, their intra and inter-specific social interaction and predation. Williamson (1974) regarded four factors, which changed the size of a population are births, deaths, immigrants and emigrants. According to Welty (1982) intra and inter specific factors and predation are significant factors to understand observed pattern of habitat selection. Since the role of above factors on Bee-eater habitatwise distributions could not be quantified presently they could not be evaluated. Certainly further research encompassing all the above will throw more light on this aspect of Bee-eater ecology.
Seasonal variations in the density of Bee-eaters could be recorded among the habitats with the river banks showing high densities during summer, the agricultural lands during pre-monsoon and the human habitation during monsoon seasons. Literature abounds with reports on seasonal variations in avian species composition and abundance (Lack 1954, Leck 1972, Winternitz 1976, Gaston 1978, Liversidge 1980, Martin 1980, Rice et al., 1980, Greenburg 1981, Karr et al., 1982, Mahabal et al., 1990). The Bee-eater breed during summer (April-June) in the study area and since the river banks provide suitable soil conditions for nest excavation, they entertain a high number of Bee-eaters during summer. Relatively high densities of Bee-eaters during pre-monsoon in agricultural lands may be attributed to the movement of newly recruited young ones together with their parents in pursuit of insect food which is abundant at the agricultural lands because of the start of the agricultural operations during that period. The high availability of insects at agricultural lands together with their significant seasonal variations (pages 27 and 28) also corroborates the above statement. On the other hand, the human habitations had high population of Bee-eaters during monsoon which suggests that the human habitation offered safer shelter for the Bee-eaters against vagaries of monsoon weather which is characterized by wind and rain frequently. Lesser activities of Bee-eaters in the human habitations during summer can be due to impossibility of breeding activities amidst human dwellings. The results of the present study very well reveal a seasonal movement pattern by the Bee-eaters, basically depending on the needs of nesting sites, food and shelter.
Bee-eater populations also showed yearwise variations (irrespective of seasons and habitats), with 1992 having higher number of Bee-eater than 1993. Various factors may be cited for yearly variations in bird densities viz., predation, intra and interspecific resource competition, parasites and diseases, habitat availability and weather (den Boer and Gradwell 1970, Andrewartha and Birch 1984, Begon and Mortimer 1986, Thiagesan 1991) as also food habits and migratory status (Lack 1966, von Haartman 1971, Newton 1980, van Balen 1980). Alternative explanations are density changes associated with variations in availability of food or unusually favourable climatic conditions (Jarvinen 1983). Territoriality or food could limit population during non-breeding seasons (van Balen 1980). Raphael (1980) stated that yearly fluctuations in bird numbers in relation to weather, could be due to changes in several other factors like winter mortality, immigration and emigration or fecundity. Annual variations in rainfall and agricultural pattern in the study area might also be the causes for such yearly variations in the Bee-eater densities.
2. Food and Feeding Habits

a. Pellet morphometry

The regurgitated pellets of *M. orientalis* had a mean length of 1.74± 0.28 cm and 0.81 ±0.09 cm of diameter and a mean weight of 0.91 ± 0.13 g. Herrera and Ramirez (1974) reported the dry weight of pellets of *M. apiaster* as 0.21± 0.088 g and Lomont (1946) and Swift (1959) gave mean weight of about 0.59 and 4 g respectively for the same species. Fry (1984) opined that the size of adult Bee-eater pellets do not vary greatly. The apparent differences in the weight of pellets might be due to differences in moistness of pellets when weighed or to possible individual or seasonal variations in pellet size (Herrera and Ramirez (1974). In the present study the Bee-eater pellets contained 16.67±5.28 prey (insect) remains per pellet. This was higher than that for European Bee-eaters, which contained 5 insect types per pellet, and 12 for red throats , according to Fry (1984). The higher number of insects per pellett in the present study must be due to greater diversity of insects in tropics than in temperate regions.

b. Prey composition

Coleopterans seem to be the principal food item of *M. orientalis* and the hymenopterans and lepidopterans ranked second and third in the order of preference , if one takes into account their relative occurrences in the pellets at different habitats, seasons and years collectively. These results are in accordance with the result of Mathew *et al.* (1978) who, based on analysis of stomach contents of Bee-eater, *M. orientalis* reported that the
Bee-eaters consumed almost equal proportions of hymenoptera, coleopterans, odonates and lepidopterans. However, Douthwaite and Fry (1982) and Fry (1984) who studied the little Bee-eater *M. pusillus*, reported that hymenopterans formed the principal diet. Douthwaite and Fry (1982) reported the diet of little Bee-eaters in Africa consisted of 57% of hymenoptera and the remainder coleoptera, diptera and odonata. Fry (1984) found that hymenopterans constituted more than 75% in the pellets of Bee-eaters with beetles constituting only 17% and the remaining 8% were termites, assassin bugs, squash bugs, shield bugs, microlepidoptera and so on. The low percentage of hymenopterans in the study area might be due to the lesser availability of bee-hives (when compared to the studies cited above). Fry (1984) also opined that the Bee-eater feeding habits were reflections of the abundance and ubiquity of prey categories.

Seasonal variations in insect remains of Bee-eater pellets showed that coleopterans were predominant during summer and hemipterans during monsoon. Seasonwise variations in the pellet composition had been reported for the little Bee-eater, *M. pusillus* in Okavango, Africa (Douthwaite and Fry 1982). Bell (1985a) observed a similar selection of smaller insects during cooler months (i.e. in times of scarcity) in thornbills near Armidale, northeastern New South Wales. Variations in the availability of insects seemed to be the cause for seasonal dietary shifts in Bee-eaters, in the study area, as there existed a perfect association between selection of a particular insect category and its availability in majority of the situations. Fry (1984) stated that Bee-eaters exploit virtually the totality of day time flying insects and opportunistically catch
whatever insects that pass by. However, estimation of Ivlev’s Electivity indices in the present study suggested that the Bee-eaters’ first preference was hymenopterans. At the outset this may look contradictory to the previous parts of this discussion; but a close scrutiny of the results of Ivlev’s indices reveal the true nature of Bee-eaters, their natural bout to go for bees (hymenoptera) as and whenever they could find them. In the event of the study area providing little scope for bee they get adapted to opportunistic feeding. However, Herrera and Ramirez (1974) cautioned that results obtained from pellet analysis of insectivorous birds can be mistaken to some extent, because Swift (1959) stated that remains of week bodied prey, such as butterflies (lepidoptera) dragonflies (odonata), and some flies (diptera), often might not be detected, small insects being digested or their remains being too small to be found. For example remains of caddies flies (trichoptera) and may flies (ephemeroptera) were detected in several analysis of stomach contents of insectivorous birds (Valverde 1967), but not in the pellets analyzed by Herrera and Remirez (1974) and also in the present investigation. It is possible that they were taken by Bee-eaters but fully digested. Numbers of week bodied prey may therefore have been under estimated. On the other hand remains of many very small hard bodied insects such as beetles (coleoptera) and bugs (hemiptera) were readily found in the pellets and their numbers could be correctly ascertained. These sources of bias are inherent to pellet analysis and as such future studies encompassing stomach content analysis would be able to provide a totally correct picture on prey selection by Bee-eaters.
c. Perch use

The small Green Bee-eater is essentially a "sit and wait" predator. Fry (1984) stated that, "the small round wing Bee-eaters obtain their food by fly catching" choosing a perch overlooking open air space where they can give unimpeded chase to any suitable insect that happens to pass by, a technique which recently has been called 'sentinel feeding'. Captures are brought back to the perch never more than one insect at a time, to be immobilized and consumed there. It is a 'sit and wait' strategy, and the birds do not actively seek out insects. Only by moving from time to time to other lookout perches nearby can such Bee-eater be said to be actively involved in hunting their prey".

The small Green Bee-eater used a variety of structures as hunting perches, the most predominant among them being telegraphic and electric wires, small walls, trees and shrubs. Perches are considered important to the habitat of many bird species especially as an essential requirement of hunting their prey (Bent 1938, Craighead and Craighead 1956). Moreover perch hunting has been regarded as one that requires little energy expenditures, as well (Wakely 1979). The importance of perches for hunting, resting and feeding as well as other activities has been well documented previously by several investigators (Forren 1981, Reinert 1984, Askham 1990). The use of perches for hunting insect prey by Bee-eater species had been reported already by Fry (1969), Douthwaite and Fry (1982) and Fry (1984). Hunt by searching from elevated perches was described for the red throated Bee-eater *M. bullocki* by Fry 1969 and for the Little Bee-eater *M. pusillus* by Douthwaite and Fry (1982) Douthwaite.
and Fry (1982) stated that *M. pusillus* searches insect prey from "elevated perches and on seeing flying insects the bird flies rapidly towards it, seizes it in the tip of the beak and glide back in an arc to the same perch". Then the prey is immobilized by beating and (in the case of a bee devenomed by wiping against the perch in *M. bullocki*). "The observations of the present study were similar to their reports.

The Bee-eater used perches of varying heights, but in general they seemed to have preferred perches of height 6-9 m and tended to hunt perching from a height of 6-9 m, as well. In *M. pusillus*, Douthwaite and Fry (1982) reported that commanding perches which barely interrupted views up to 200 or 300 m were favoured and stated further that the perch height seemed to be dependent upon the type of ground vegetation in the feeding grounds. A perching height of 6-9 m is the optimum height that fulfilled the above criteria in the study area and as such the preferred perch height of *M. orientalis* appears to be in accordance with the findings for *M. pusillus* by Douthwaite and Fry (1982). However, one must bear in mind that the nature and height of perches used might also be related to the type of prey captured and their seasonal variations as well, as reported in thornbills by Bell (1985a, b).

d. Foraging height

The small Green Bee-eater caught most of its insect prey (53.96%) at heights (foraging height) of about <3 m above ground level (Table 16). This was in accordance with the statement of Douthwaite and Fry (1982) that *M. orientalis* and *M. pusillus* are the two species that feed
mainly nearer to the ground levels than any of their congeners. However, studies by Blakers et al. (1984) and Brookers et al. (1990) on insectivorous birds showed that insectivorous birds in general are height generalists. The apparent disagreement to the above generalization with regard to *M. orientalis* in the present study might be due to selection of specific type of prey, feeding behaviour, and the habitat types available in the study area which are relatively open with dispersed vegetation.

e. Foraging substrate

The small Green Bee-eater was essentially an aerial feeder since 81.19% of food captured were insects from air. This is in accordance with the general descriptions for Bee-eaters by Fry (1984) who stated that the Bee-eaters in general are flycatchers* M. orientalis* nevertheless did not deviate from its congeners in this aspect. Ground feeding was found to be minimized for *M. orientalis* in the present study. Similar reports were given for *M. pusillus* by Douthwaite and Fry (1982) who stated that the little Bee-eaters never took prey from the ground. *M. orientalis* in the present study took only one insect per attempt and in this respect resembled *M. pusillus* (Douthwaite and Fry 1982), but was in contrast to the layer species such as European, Blue cheeked and Carmine Bee-eater, *M. apiaster, M. persicus* and *M. nubicus* respectively, which feed aloft taking one insect after another in continuous flight without returning to the perch (Fry 1984).
f. Plant substrates

Whenever the small Green Bee-eater *M. orientalis* fed on insects from plant substrates, they predominantly did so from herbs (57.39%) and avoided dense foliage either in the form of trees or shrubs. Fry (1982) explained this foraging behaviour of Bee-eaters by stating that true fly catchers and other small insectivores, like Bee-eaters, need space to manoeuvre to catch fast flying hymenoptera and so they shun dense foliage.

3. Time Activity Budget

**Bee-eater**

Time activity budget studies quantify the time animals allocate to different activities. Such studies can also increase our understanding of habitat use and niche separation among species because natural selection should favour individuals that best apportion their time among each activity, habitat and climatic condition (Verner 1965, Titman 1981). The Bee-eaters' activity pattern varied significantly between habitats and seasons (Table 25) The time spent on feeding was significantly influenced by the interaction between habitats and seasons, indicating that feeding activity differed seasonwise in different habitats. The habitatwise variations in the percent time spent on feeding might be due to variations in food availability. Hutto (1990) stated that food availability was the major factor that caused variations in the time spent on feeding. However, time budgets may also change independently of food availability because of changes in (micro) habitats (Robinson and Holmes 1984), season and weather (Grubb 1978).
Changes in activity budgets are often used to determine seasonal differences in behaviour as well (Quinlan and Baldassarre 1984, Bergan et al., 1989). In fact the Bee-eaters showed a seasonwise difference also in their activity pattern. Seasonal changes in foraging behaviour of birds has already been reported by Ford et al. (1990). However, the above author cautions that identification of seasonal changes in foraging behaviour in birds is only the first step to open up a whole series of interesting questions on the factors that influence the bird behaviour such as the role of predator avoidance, stage of breeding cycle, phenological stage of vegetation etc. In all the habitats, the Bee-eaters spent less time in feeding during winter, and the percent time spent on feeding in a day steadily increased up to summer months, showing a correlation with an increase in day time during those months. Bergan et al. (1989) also stated that seasonal variations in birds might be a response to the lengthening of photoperiod.

Flying activity reached a peak during summer whereas resting was more during winter months. This showed the activity pattern of Bee-eaters varied following the ambient temperature which usually was low during monsoon and high during summer. Paulus (1980) observed similar trends for godwalls, i.e., a positive correlation between locomotion and temperature and resting. Quinlan and Baldassarre (1984) opined that such a relationship in the green winged teal might be due to the fact that the birds rested more, presumably to conserve energy when temperatures were low.
In general the Bee-eaters had a bimodal pattern of feeding activity, one peak in the morning and another in the evening during all the seasons and in all the habitats. The morning peak was high in summer while the evening peak was high during monsoon, probably due to relatively late sunrise during monsoon months, so that the birds may be forced to feed more in the evening time to pass relatively longer nights during the same time. Time activity pattern of the small Green Bee-eater could not be compared to any previous study because of absence of reports on this aspect on congeneric species (Herrera and Ramirez 1974, Douthwaite and Fry 1982, Fry 1984, Krebs and Avery 1984, Avery et al., 1988, Lessells and Krebs 1989, Wrege and Emlen 1991, Crick 1992). However time activity budgets seemed to be species specific, considering the reports on the time activity budgets of various bird species (e.g., Orians 1961, Sjefried 1972, Stendell 1972, King 1974, Dwyer 1975, Green 1976, Verbeek 1977, Wakely 1978, Sjoberg 1985, Lo and Fordham 1986).

4. Comparison of Time Activity Budgets of the Three Bird Species

The monthly and daily activity patterns of the three bird species showed habitatwise and seasonwise variations indicating that these bird species had greater time flexibility in adjusting their time budgets to variations in the habitat and climatic conditions. All the three bird species showed two peaks in their feeding activity one in the morning and another during late evening, perhaps due to their preference for similar insects i.e., the insects that are active during these time periods. Sjoberg (1985) had stated that the activity pattern of a bird might be related to the activity of the prey. This is confirmed by the present study.
5. Foraging Niche Overlap with Black Drongo and the Blue Jay:

All the insectivorous birds whose foraging behaviour had been compared viz., the small Green Bee-eater, the black Drongo and the Blue jay were predominantly aerial feeders as they obtained 81.10%, 76.10% and 72.30% of their food from air by fly catching, respectively. This showed that they all belong to the fly catching guild of insectivorous birds. This further indicated that their insect prey were almost the same. Gause’s (1934) principle, which was later refined as competitive exclusion (Hardin 1960), states that no two species can coexist on the same area indefinitely with identical food requirements. Avian ecologists have often demonstrated and Lack (1971), reviewed how closely related species found coexisting in the same area are separated ecologically by resource partitioning. The above species thus must have some sort of resource partitioning among themselves in order to coexist in the same habitat. The resource partitioning in avian communities is a concept that has been intensively studied (Cody 1974, Ulfstrand 1976, Alatalo 1978, Wiens and Rotenberry 1979) and the primary aim of these studies were to obtain the basis of niche separation. So the basis of resource partitioning in the birds presently studied was evaluated by estimating the overlaps in their foraging behaviour characteristics viz., perch types and characteristics, foraging heights and foraging substrates, foraging plants, foraging position on trees and foraging method. Very high overlaps ranging from 0.638 to 0.968 were observed between the above species with reference to various foraging parameters (Table 23).
Niche overlap is a joint use of a resource by two or more species Colwell and Futuyma (1971); it is the region of niche space (in the sense of Hutchinson 1958) shared by two or more contiguous niches. The high overlaps between these species indicated that there exists a high degree of competition. Miller (1967) stated that competition between two species depends on the amount of intersection that exist between their fundamental niches and that one or a few key factors may govern the competitive interactions between two species, even though the total niche of any species is a multidimensional configuration of many variables. In order to understand the basis of niche segregation, Principal Component Analysis of variance was carried out. When the variables of foraging behaviour were subjected to Principal Component Analysis, three components could be delineated. Component I was perch characteristics (including perch types and heights and perching heights). Component II was feeding method (Feeding substrate and feeding method) and Component III was feeding height. The Bee-eaters differed from the other two species by using relatively lower perches, obtaining food more by aerial hawking and feeding on insects at comparatively higher heights in the air. Faaborg (1988) stated that ecological separation in diverse assemblage of birds is achieved through differences in body size, foraging time, foraging behaviour, and bill size and shape, all of which affect the type of prey captured. From the foregoing analysis it seemed that the small Green Bee-eater is ecologically separated from the other two primarily by differences in feeding behaviour, in addition to overt differences in body size, bill size and shape.
6. Breeding Ecology

The Bee-eater, *M. orientalis* has a single brood from March to June. Baker (1934) cited by Fry (1984) reported similar observations for the same species in India.

**a. Nest cavity characteristics**

Bee-eaters are reported to excavate a long tunnel with terminal nest chamber in soil. A few species habitually used vertical cliffs for this purpose but several others habitually nested in flat ground, yet other species used both situations (Crick and Fry 1980). Ali and Ripley (1983) reported that the small Green Bee-eater *M. orientalis* builds a (nest) tunnel of 3-4 cm diameter horizontally in an earth mound or sandy cutting or in sides of a borrow pit and the like, often driven obliquely in almost flat sandy ground, singly or in a scattered colony. They (op. cited) further observed that the Bee-eater tunnels usually measure from half a meter to 2 meters long ending in a widened egg chamber which are unlined but often littered with chitinous insect remains. Similar nest cavity features were recorded in the present study area also.

In the present study the nest entrance had a mean diameter of 6.33± 0.63 cm while the length of the nest hole was 112.12± 21.00 cm. These measurements are more less similar to those reported by Ali and Ripley (1983) and Fry (1984). The diameter of the burrow entrance was 3-4 cm as reported by Ali and Ripley (1983) and 5-6 cm as per Fry (1984) while the length of the nest hole was reported to be 0.5-2.0 m by Ali and
Ripley (1983) and by Fry and Fry (1992). In the present investigation the brood chamber of *M. orientalis* had a mean length of 15.87±3.26 cm; diameter of 8.52±4.21 cm and height of 13.13±5.63 cm and the above measurements were 15 cm, 12 cm, 9 cm respectively according to Fry (1984). Thus the results of the present study in respect of brood chamber is more in agreement with those of Fry (1984).

Nests of *M. orientalis* were abundant in the river banks than in other habitats may be due to the nature of the soil i.e., loose and sandy soil suitable for nest excavation. On the other hand the soil is more clayey in the agricultural lands which is not suitable for the Bee-eaters to excavate nests. In the human habitations though soil type is more or less similar to that of river banks, one can not expect Bee-eaters to nest amidst human disturbances. Burton *et al.* (1994) opined that easy access to and from the nests appears to be most important for birds and the birds are no exception to this feature. Aumann (1989) suggested that proximity of nests to water course may facilitate access the nest area, allow early warning of intruders or may be related to local prey concentrations in those areas. Ecotones are good spots for hunting with high prey availability (Burton 1992). Thus the abundance of nest cavities along the river banks could be related to the above said factors.

**b. Morphometry of eggs**

*M. orientalis* was found to lay small eggs with mean length, and width of 2.10±0.01 cm; 1.80±0.49 cm and weighed 2.62±0.33 g. According to Baker (1934) quoted by Fry (1984) and Ali and Ripley
(1983), the egg measurements for *M. orientalis* i.e., mean length and width were 1.93 cm (range 1.75-2.14 cm) and 1.73 cm (range 1.58-1.80 cm). The egg measurements in the present study are in full agreement with those of the previous reports.

c. Clutch size

The Bee-eaters had a clutch size ranging from 2-5 with a mean of 4.00. Ali and Ripley (1983) reported that the clutch size of *M. orientalis* as 4-7 with a mean of 6.00. Several factors might contribute to clutch size variability, viz., the condition or state of breeding female, the availability of resources necessary to produce eggs, the presence of helpers at the nest, the time of laying in the season, and the anticipated future availability of food for feeding nestlings (Klomp 1970, Cody 1971, O' Connor 1984) as food supply was considered to be the main determinant of clutch size (Lack 1968, Klomp 1970, Blondel et al., 1987). The lower clutch size in the present study might perhaps be due to lesser prey availability. Two factors viz., the insect availability (insect abundance in the month before laying) and the rainfall over the 3 month period before laying accounted for 16% of variations in clutch size in the case of white fronted Bee-eater (*M. bullockoides*) (Wrege and Emlen 1991). Further during 1992, the study area experienced a heavy rainfall leading to a cyclone with far reaching consequences on fauna and flora in the study area and this might have had a possible impact on the fecundity of birds. Since data on insect availability in the study area during the previous years are not available, the above is only a speculation. Lessells and Krebs (1989) indicated that among Bee-eaters (*M. apiaster*) the clutch size was also
related to the age of the female. Further they added that adult females laid clutches that were about half an egg larger than those of younger ones. Such a study of clutch size was not made presently.

d. Hatching success

The mean overall hatching success as recorded in the present study was 78.81 ± 33.93%. Egg losses were mainly due to human disturbances. Majority of altricial bird species hatch their young asynchronously (Clark and Wilson 1981) because incubation begins before the clutch is complete and the eggs therefore hatch over a period of one or more days in approximately the order in which they were laid (Haftorn 1981, Zach 1982, Blank and Nolan 1983, Braun and Hunt 1983, Mead and Morton 1985). In six tropical species for which incubation and hatching synchrony are known, all appear to begin partial incubation with the first egg, and successive eggs hatch at approximately 24 hrs intervals (Dyer 1979, Fry 1984 and Wrege and Emlen 1991). During the present study also the incubation and hatching sequence was found to be asynchronous. Further, the late hatchlings were found to die in many instances. In white fronted Bee-eater, *M. bullockoides*. Wrege and Emlen (1991) also observed hatching to be asynchronous. This enhanced the ability of older nestlings to monopolize limited food supplies, and resulted in the selective death of the smallest nestlings first. Such brood reduction coupled with the ability of nestlings to slow their development rate in response to food stress, is considered as adaptation for coping with the unpredictable variation in food supplies commonly met by these birds (Wrege and Emlen 1991).
e. Fledging success

The overall mean fledging success of *M. orientalis* was 79.13±25.45%. These values were relatively more than those reported for *M. bullockoides* (41%) by Wrege and Emlen (1991) This showed that the lower clutch size for *M. orientalis* in the present study was compensated by relatively high fledging success, thereby ensuring overall reproductive success of this species. Further, Lessells and Krebs (1989) reported that among *M. apiaster* fledging, as or nearly as, asynchronous as hatching, the last chick to leave fledges about 32 days after the first chick hatches and 28 days after the last, at an age independent of hatching asynchrony. In the case of *M. orientalis* fledging was found to occur from 25-28 days. Lessells and Krebs (1989) reported that the Bee-eaters continue to feed their young even after fledging because the capture of fast flying insects is a skill which may require time to acquire, and as such Bee-eater chicks presumably continue to be dependent on their parents for sometime after fledging.

f. Morphometry of nestlings and nestling growth

Periodical monitoring of the nestlings of *M. orientalis* in respect of their morphometric details such as weight, bill length, tarsus length, caudal length, wing chord length, wing span and total body length revealed progressive changes during growth. The weight of chicks on the first day was 2.55± 0.21 g which increased to 22.28±4.39 at 26 days of age. However there was a drop in the mean weight of chicks at 21-23 days. Fry *et al.* (1984) also showed a significant weight loss before
fledging in the nestlings of white fronted Bee-eater, *M. bullockoides* and red throated Bee-eater, *M. bullocki*. Wing (1956) attributed such a prefledging loss in body weight to the loss of heat, loss of the feather sheaths and desiccation of the feather pulp. He further stated that hardening of bone and tissue, other physiological changes in the body, and less feeding by the adults at the time may also contribute to the weight loss.

**g. Polynomial regression lines**

Polynomial regression equation when fitted into the weight and wing length of chicks indicated that the growth pattern is almost similar in all the three chick categories viz., "early", "middling" and "late" chicks (Figs. 31 and 32). The mean body weight deviation was \(-0.368 \pm 0.057\) (Table 37) in the 'late' chicks whereas it was \(0.277 \pm 0.067\) for 'early' chicks which indicated that the size hierarchy established as a result of hatching asynchrony was exacerbrated by differences in the growth rates of chicks. More or less similar observations were reported by Lessells and Avery (1989) also for European Bee-eaters.
7. **Management Implications and Suggestions for Future Research**

The present study brought out a new dimension to the ecology of the small Green Bee-eater, *M. orientalis* as 1) they occur in good numbers in the agricultural lands wherein large scale cultivation of paddy, sugarcane, pulses etc., are going on, and 2) they seem to feed on a wide variety of insect pests. However, in the present investigation, the insect prey were not identified upto species level and therefore studies on that line would definitely throw more light on this aspect of small Green Bee-eater, *M. orientalis* i.e., as a biocontrol agent against harmful insects of agriculture.

So, the following suggestions are given for future research on this species and its management:

1. Identification of insect food items of the small Green Bee-eater *M. orientalis* upto species level and the proportion of agricultural insect pest species in their diet.

2. Habitat improvement such as provision of perches amidst crops could be attempted in order to attract more Bee-eaters into the crop lands and thereby possibly giving protection to the crops against insect pests. The evaluation of such a practice might also be a potential for future research.

3. Enlightening the local Public on this bird's economic value is also needed as it will go a long way in improving its population since majority of its egg-losses in the study area were due to human interference.